Influence of snoring on in incidence of metabolic syndrome: a community-based prospective cohort study in rural Northeast China

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Abstract

Background: There is increasing trend of metabolic syndrome (MetS) in rural areas of China in recent years. It is necessary to figure out the possible risk factors of MetS for better intervention. This community-based prospective cohort study was performed to assess the relationship between snoring status and incidence of MetS.

Methods: We conducted a cohort study among residents aged ≥ 35 years without MetS in 2012-2013. Among 5,691 residents who met the inclusion criteria, 4,980 residents (2,586 men and 2394 women; follow-up proportion: 87.5%) remained available for follow-up examinations during 2015-2017. The main outcome was the incidence of MetS, defined by the unify criteria in 2009. We divided residents by snoring status and compared outcome between groups. Using a logistic regression model, we estimated the odds ratio (OR) for incidence for MetS, adjusting for confounders, ages, gender, exercise habit, sleep duration, alcohol and smoke consumption.

Results: With a median follow up of 4.6 years, incidence of MetS was higher in snorers (men 26.2%, women 33.5%) than in non-snorers (men 19.7%, women 23.2%). Diastolic blood pressure increased in follow-up compared with baseline in male snorers but decreased in male non-snorers. Similarly, fast blood glucose level increased in female snorers at follow-up but decreased in female non-snorers. We found a significant association between snoring and incidence of MetS (adjusted OR=1.51, 95%CI=1.32-1.74). Besides, as the degrees of the snoring increased, the incidence of MetS increased simultaneously. And the OR for the very severe snoring was double compared with non-snorers (adjusted OR=2.10, 95%CI=1.38-3.20).

Conclusion: Snoring is associated with higher incidence of MetS in rural Northeast Chinese. More emphasis should be paid to residents with snoring problem.

Background

Sleep disorders are prevalent around the world in both adults and children and worse among ages [1–3]. Snoring as the most severe form of sleep disorders, can be a precursor of obstructive sleep apnea (OSA) [4]. Many previous studies have reported that sleep disorder and snoring are relevant to many metabolic disorders like hypertension, diabetes and many cardiovascular diseases like coronary heart diseases, stroke or even cancer [5–7]. MetS is the combination of abdominal obesity, hyperlipidemia, elevated blood pressure, and insulin resistance with a higher risk of cardiovascular events and mortality [8, 9]. Residents lived in rural area of China have their own specific lifestyle and habit. Our previous study have reported a relative high prevalence of metabolic diseases like hypertension (51.1%; 53.9% for men and 48.7% for women), diabetes (10.6%; 10.0% for men and 11.1% for women), and dyslipidemia (36.9%) among residents from rural Northeast China [10, 11]. In order to handle those metabolic disorders, many strategies were carried on like dietary and lifestyle regulation, health education propagation, and proper medication treatment. However, there is still some risk factors that are lack of our attention. One of them is the snoring status. In rural areas, few residents concerned their sleep situation not to mention the snoring status. Hence, in the present study, we aimed confirmed the possible relationship between snoring status and the incidence of MetS. Therefore, we can better handling the risk other than the traditional ones.

Methods

Study design and setting

The Northeast China Rural Cardiovascular Health Study (NCRCHS) is a community-based prospective cohort study carried out in rural areas of Northeast China. The design and inclusion criteria of the study has been described previously [12, 13]. In brief, a total of 11,956 participants aged ≥ 35 years were recruited from Dawa, Zhangwu and Liaoyang counties in Liaoning province between 2012 and 2013, using a multi-stage, randomly stratified cluster-sampling scheme. Detailed information was collected at baseline for each participant. In 2015 and 2017, participants were invited to attend a follow-up study. Of the 11,956 subjects, 1,256 participants were not included due to missing contact information and 10,349 participants (86.6%) completed at least one follow-up visit. The study was approved by the Ethics Committee of China Medical University (Shenyang, China). Written informed consent was obtained from all participants. The detailed inclusion process of participants is shown in Fig. 1.

Study Variables

At baseline, detailed information on demographic characteristics, dietary and lifestyle factors and medical history were obtained by interview with a standardized questionnaire [14]. Smoking and drinking status were defined as current use. Regular exercise defined using question as "whether exercise regularly" in the questionnaire and the answer is yes = 0 and no = 1. Snoring assessment was collected from residents themselves together with bed partner or family member. Snoring intensity was evaluated as mild (louder than breathe sound), moderate (similar as talking sound), severe (louder than talking sound), very severe (very nosy, can be heard in the next room). Sleep time was considered as the total hours of sleep in 24 hours. Weight and height were measured with participants in light weight clothing and without shoes. Waist circumference was measured at the umbilicus using a non-elastic tape. Body mass index (BMI) was computed as weight in kilograms divided by the square of height in meters. Obesity was defined as BMI ≥ 28 kg/m^2[15]. Blood pressure was assessed three times with participants seated after at least 5 min of rest using a standardized automatic electronic sphygmomanometer (HEM-907; Omron, Tokyo, Japan). Hypertension was defined as systolic blood pressure (SBP) ≥ 140 mm Hg and/or diastolic blood pressure (DBP) ≥ 90 mm Hg, and/or use of antihypertensive medications [16]. Fasting blood samples were collected in the morning from participants who had fasted at least 12 h. Fasting plasma glucose (FPG), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglyceride (TG), serum creatinine and other routine blood biochemical indexes were analyzed enzymatically. Estimated glomerular filtration rate (eGFR) was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation [17]. MetS was diagnosed follow the unify criteria from the meeting between several major organizations in 2009 [8]: The presence of any 3 of 5 risk factors constitutes a diagnosis of metabolic syndrome. 1. Elevated waist circumference (population- and country-specific definitions): ≥90 cm for men; ≥80 cm for women (Asians; Japanese; South and Central Americans); 2. Elevated triglycerides (drug treatment for elevated triglycerides is an alternate indicator): ≥150 mg/dL (1.7 mmol/L); 3. Reduced HDL-C (drug treatment for reduced HDL-C is an alternate indicator) : <40 mg/dL (1.0 mmol/L) in men; <50 mg/dL (1.3 mmol/L) in women; 4. Elevated blood pressure (antihypertensive drug treatment in a patient with a history of hypertension is an alternate indicator): Systolic ≥ 130 and/or diastolic ≥ 85 mm Hg; 5. Elevated fasting glucose (drug treatment of elevated glucose is an alternate indicator): ≥100 mg/dL;

Statistical analysis

Descriptive statistics were calculated for all the variables, including continuous variables (reported as mean values and standard deviations) and categorical variables (reported as numbers and percentages). The residents were divided into two groups: non-snorers (n = 3332) and snorers (n = 1640). Changes in body weight, BMI and other parameters at baseline and follow-up between this two groups were compared using Student's t-test or a Wilcoxon rank sum test. We used logistic regression analyses to estimate odds ratio (ORs) and 95% confidence intervals (CIs) for the relationship between snoring and MetS after adjusting for possible confounders. The logistic regression model included the following variables: age (continuous), snoring status (non-snorers or snorers), sleep duration (continuous), eGFR (continuous), regular exercise (yes or no), current smoking status (yes or no), current drinking status (yes or no). All the statistical analyses were performed using SPSS version 17.0 software, and P values less than 0.05 were considered to be statistically significant.

Results

Clinical characteristics

The baseline characteristics of the 4,980 residents (2,586 men and 2394 women; follow-up proportion: 87.5%; follow-up period: 4.6 year) are listed in Table 1. Among women, weight, BMI, waist circumference, SBP, DBP, TC, TG, HbA1c and LDL were higher and eGFR was lower at baseline in snorers then in non-snorers, while only weight, BMI, waist circumference and DBP were higher at baseline for men in the snorers versus the non-snorers. In addition, the rate of current drinker was significantly higher in snorers in men while the rate of current smoker was higher in snorers in women.

Changes in Clinical Characteristics at baseline and follow-up by snoring status

Table 2 shows changes in clinical characteristics at baseline and follow-up by snoring status. For men, there is great increase of DBP in the follow-up in snorers while decrease is seen in the non-snorers. There is a relatively smaller decrease of SBP in snorers compared with non-snorers in follow-up. As for women, we only can see a significant increase of FBG at follow-up in snorers while in non-snorers FBG decreases in follow-up compared with baseline. For both genders, there is higher decrease of current smoker from follow-up to baseline in snorers compared with non-snorers.

Impact Of Snoring Status On Incidence Of Mets

Crude incidence proportion of MetS was significantly higher in the snorers group [men: 26.2% (271/106), women: 33.5% (205/612)] than in the non-snorers [men: 19.7% (305/1550), women: 23.2% (413/1782)]. Logistic regression analysis estimated a significant relationship between snoring statuses and incidence of MetS, even adjusting for possible confounders like age, baseline clinical characteristics, and life style [adjusted OR (95%CI): 1.51(1.32–1.74); Table 3]. We performed an additional subgroup analysis by gender and found that the significant relationship between snoring status and incidence of MetS persisted in both men and women [adjusted OR (95%CI) in men: 1.43(1.19–1.73); OR (95%CI) in women: 1.505(1.23–1.85); Table 4]. As we seen in the Fig. 2A. As the degree of snoring increased, the rate of MetS increase simultaneously (26.5% for mild; 29.5% for moderate; 29.6% for severe; 35.3% for very severe).

Another subgroup analysis by the degrees of snoring also revealed that a significant association between snoring degree and incidence of MetS [adjusted OR (95%CI) in mild: 1.34(1.10–1.64); adjusted OR (95%CI) in moderate: 1.57(1.29–1.92); adjusted OR (95%CI) in severe: 1.56(1.22–1.98); adjusted OR (95%CI) in very severe: 2.10(1.38–3.20);].

Discussion

The present study confirmed that with a median follow up of 4.6 years, incidence of MetS was significantly higher in snorers (men 26.2%, women 33.5%) than in non-snorers (men19.7%, women 23.2%). After adjusting for possible confounders, a significant association was found between snoring status and incidence of MetS. Besides, as the snoring degree increased, the incidence of MetS increased simultaneously. Value of Odd ratios was double in very severe snoring when compared with non-snorers. In addition, we found that SBP decreased less dramatically in the follow-up among male snoring than among male non-snorers. On the contrary, DBP in male snorers and FBG in female snorers even significantly increased in the follow-up when comparing to non-snorers (Table 2). Taken together, these results suggest that snoring might lead to higher risk of MetS, and we should therefore focus more on sleep disorder especially snoring status of residents from rural areas.

MetS had been proved to increase the risk of cardiovascular and cerebrovascular diseases. Many factors were relevant to the cause of MetS like unhealthy diet habit, sedative lifestyle, smoking and drinking habit. Early detection and intervention were useful to reduce incidence of this diseases. As far as we know, most of the interventions were focus on lifestyle changing like more exercise, higher consumption of vegetables instead of high fat food. Less concern had been put on the sleep disorder especially on snoring status. This study reported a high rate of self-reported snoring (31.1%) at baseline in rural Northeast Chinese. This was higher than most of the previous studies, 14.14% in southeast Chinese in Fujian Province, 15.5% in south Chinese in Guangdong Province [18, 19]. As a community-based prospective cohort study, data from our study confirmed that among rural residents, snoring status had closed relationship with the incidence of MetS in both women and men. Similarly, the relationship between snoring and MetS had been proved by many previous studies. Among Korean adults, there was a clear dose-response relationship between increasing frequency of snoring and higher prevalence of each metabolic components in both women and men [20]. Similarly, in rural communities from Korean, there was an increasing trend of ORs for MetS of different snorers (OR for rare snoring: 1.42; OR for occasional snoring: 1.79; OR for habitual snoring: 2.03) [21]. There existed an apparently elevated trend based on snoring frequency in the prevalence of metabolic disorders among residents from Southeast China. This association still significant even adjusted for possible confounding factors [22]. Other study have found a relationship between snoring and hypertension. [23–26]. Data from our study showed that in male, the decrease of SBP was relatively smaller in snorers when compared with non-snorers. As for DBP, it even showed a significantly increasing trend in snorers. In female residents, FBG decreased in non-snorers but increased in snorers. A prospective study enrolled 69,852 US female without diabetes at baseline came out with 1,957 diagnosed with type II diabetes after 10 years follow-up. Further analysis revealed that snoring was associated with risk of diabetes after adjusting possible confounders [27]. Hence, the possible of higher incidence of MetS among women snorers might be relevant to the increasing trend of FBG. The mechanism underlying the association between snoring and metabolic disorders had not been fully understand. One possible reason might be the intermittent hypoxia and sleep deprivation coming from snoring inducing sympathetic nervous activation, chronic inflammation, oxidative stress which increase the risk of insulin resistance, elevate blood pressure, leading to MetS [28, 29].

There are some limitations that we need to issue in the present study. First, we used self-reported questionnaires rather than objective measurements which limited the reliability of the study findings. However, there are already many previous studies have reported the association between self-reported snoring and various clinical outcomes [30, 31]. Secondly, our sample only enrolled rural residents from Northeast China. Therefore, the diversity might be imitated.

In the present study, we confirmed the increasing incidence of MetS among snorers compared with non-snorers. Therefore, for early detection of MetS, it is necessary to assessed sleeping situation especially snoring status. And except for lifestyle adjustment, more concerning should be put on handling snoring problems. Besides, special attention should be paid to the presence of metabolic disorders in snorers.

Abbreviations

MetS:metabolic syndrome; OR:odds ratio; OSA:obstructive sleep apnea; BMI:Body mass index; SBP:systolic blood pressure; DBP:diastolic blood pressure; FPG:Fasting plasma glucose; TC:total cholesterol; LDL-C:low-density lipoprotein cholesterol; HDL-C:high-density lipoprotein cholesterol; TG:triglyceride; eGFR:Estimated glomerular filtration rate.

Declarations

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Authors' Contributions

SSY contributed to the data collection, analysis and interpretation. XFG and HMY contributed to data collection. GXL and SSY contributed to data analysis. YXS contributed to the study conceptions and design. All authors read and approved the final version of the manuscript.

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Availability of data and materials

Enquiries regarding the availability of primary data should be directed to the principal investigator Professor Yingxian Sun (sunyingxian12@aliyun.com).

Ethics approved and consent to participate

The study was approved by the Ethics Committee of China Medical University (Shenyang, China AF-SDP-07-1, 0-01). All procedures were performed in accordance with ethical standards. Written consent was obtained from all participants after they had been informed of the objectives, benefits, medical items and confidentiality agreement regarding their personal information.

Consent for publication

All the participants gave consent for direct quotes from their interviews to be used in this manuscript.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1. Baseline characteristics of subjects with or without snoring

	Men			Women		
	Nonsnorers	Snorers	P values [i]	Nonsnorers	Snorers	P values [i]
Participants, n	1550	1036		1782	612	
Incidence of MetS	305(19.7)	271(26.2)	<0.001	413(23.2)	205(33.5)	<0.001
Age, years	54.51(11.03)	53.88(9.78)	0.139	50.12(9.61)	53.21(8.97)	<0.001
Height, (cm)	165.75(6.47)	166.13(6.45)	0.142	155.82(6.08)	155.46(6.44)	0.216
Weight, kg	64.21(8.60)	66.76(9.16)	<0.01	56.38(8.67)	58.65(9.84)	<0.001
BMI [a] (kg/m^2)	23.37(2.94)	24.19(3.13)	<0.01	23.20(3.23)	24.25(3.67)	<0.001
Waist circumference (cm)	79.51(7.71)	81.27(8.15)	<0.01	75.68(8.04)	78.59(9.08)	<0.001
SBP [b] (mmHg)	139.60(21.97)	140.36(21.63)	0.385	131.93(20.83)	135.80(22.36)	<0.001
DBP [c] (mmHg)	81. 01(10.87)	82.28(11.36)	0.004	77.42(10.46)	78.91(10.88)	0.003
FPG [f] (mmol/L)	5.61(1.14)	5.65(1.25)	0.387	5.37(0.90)	5.39(0.82)	0.603
TC [g] (mmol/L)	5.07(0.98)	5.12(0.94)	0.198	5.07(1.00)	5.28(1.05)	<0.001
TG [h] (mmol/L)	1.18(0.99)	1.17(0.69)	0.861	1.08(0.58)	1.15(0.50)	0.004
HDL-C [d] (mmol/L)	1.52(0.42)	1.50(0.43)	0.366	1.54(0.34)	1.54(0.34)	0.922
LDL-C [e](mmol/L)	2.80(0.74)	2.85(0.74)	0.070	2.79(0.76)	2.95(0.83)	<0.01
eGFR (mL/min/1.73 m^2)	95.61(12.75)	96.18(14.82)	0.299	95.59(14.82)	93.69(14.73)	<0.001
HbA1c	5.22(0.85)	5.31(0.90)	0.210	5.16(0.64)	5.32(0.59)	0.007
Sleep time (hours)	7.38(1.62)	7.47(1.56)	0.217	7.12(1.69)	7.10(1.75)	0.758
Current smoker (%)	58.6	60.5	0.181	14.8	21.1	<0.001
Current drinker (%)	43.5	51.4	<0.001	2.6	3.9	0.073
Regular excise (%)	19.2	18.8	0.436	17.3	19.6	0.115

All values in parentheses represent the standard deviation. [a] Body Mass Index, [b] Systolic Blood Pressure, [c] Diastolic Blood Pressure, [d] High-Density-Lipoprotein-Cholesterol, [e] Low-Density-Lipoprotein Cholesterol, [f] Fasting Plasma Glucose, [g] Total cholesterol, [h] Triglyceride. [i] P values were calculated by t-test (continuous variables), Wilcoxon rank sum test (continuous variables), or chi-squared test (categorical variables).

Table 2. Changes in clinical characteristics with or without snoring.

	Men			Women		
	Nonsnorers	Snorers	P values	Nonsnorers	Snorers	P values
Participants, n	1550	1036		1782	612	
Incidence of MetS	305	271	<0.001	413(23.2)	205(33.5)	<0.001
△ Weight, kg	0.09	0.12	0.893	0.33	0.61	0.281
△ BMI [a] (kg/m^2)	0.85	0.92	0.524	-0.38	-0.34	0.764
△ Waist circumference (cm)	3.96	4.08	0.526	3.82	4.35	0.122
△ SBP [b] (mmHg)	-3.68	-2.04	0.024	-4.58	-5.07	0.555
△ DBP [c] (mmHg)	-0.45	0.51	0.012	-1.11	-0.06	0.763
△ FBG [f] (mmol/L)	0.07	0.09	0.672	-0.06	0.06	0.003
△ TC [g] (mmol/L)	-0.29	-0.33	0.336	-0.29	-0.28	0.895
△ TG [h] (mmol/L)	0.24	0.32	0.135	0.27	0.31	0.306
△ HDL-C [d] (mmol/L)	-0.08	-0.10	0.148	-0.08	-0.08	0.624
△ LDL-C [e] (mmol/L)	0.19	0.17	0.501	0.22	0.25	0.456
△ eGFR (mL/min/1.73 m^2)	-3.24	-2.62	0.176	0.04	0.21	0.776
△ Current smoker (%)	-2.4	-5.0	<0.001	-1.0	-7.3	<0.001
△ Current drinker (%)	2.4	2.8	0.476	1.4	2.0	0.126

All values in parentheses represent the standard deviation. [a] Body Mass Index, [b] Systolic Blood Pressure, [c] Diastolic Blood Pressure, [d] High-Density-Lipoprotein-Cholesterol, [e] Low-Density-Lipoprotein Cholesterol, [f] Fasting Plasma Glucose, [g] Total cholesterol, [h] Triglyceride.

Table 3. Association between snoring status and incidence of MetS.

	ORs (95%CIs)	
	Crude	Multivariate
Snoring (ref: no)	1.48(1.29-1.69)	1.51(1.32-1.74)
Men (ref: women)	1.21(1.07-1.38)	0.68(0.58-0.80)
Age (1-year increase)	1.02(1.01-1.02)	1.02(1.01-1.03)
eGFR (1-mL/min/1.73 m^2 increase)	0.99(0.98-0.99)	0.99(0.99-1.00)
Sleep duration (1-hours increase)	1.01(0.97-1.05)	1.03(0.99-1.07)
Exercise (ref: no)	1.17(0.99-1.38)	1.06(0.89-1.26)
Current smoker (ref: never or former smoker)	0.91(0.80-1.04)	0.94(0.81-1.10)
Current drinker (ref: never of former drinker)	1.01(0.87-1.17)	1.20(1.00-1.44)

CI, confidence interval; OR, odds ratio

Table 4. ORs (95%CIs) for incidence of MetS in the follow-up (gender subgroup analysis); relationship between snoring status and incidence of MetS.

	OR (95%CI)			
	Men		Women	
	Crude	Multivariate	Crude	Multivariate
Snoring (ref: no)	1.45 (1.20-1.74)	1.43 (1.19-1.73)	1.67 (1.37-2.04)	1.51 (1.23-1.85)
Age (1-year increase)	1.00 (0.99-1.01)	0.99 (0.99-1.01)	1.04 (1.03-1.05)	1.04 (1.03-1.05)
eGFR (1-mL/min/1.73 m^2 increase)	0.99 (0.98-0.99)	0.99 (0.98-1.00)	0.99 (0.98-0.99)	1.00 (0.99-1.01)
Sleep duration (1-hours increase)	1.01 (0.96-1.07)	1.02 (0.96-1.08)	1.01 (0.96-1.07)	1.06 (1.00-1.12)
Exercise (ref: no)	1.04 (0.82-1.31)	1.01 (0.79-1.29)	1.33 (1.06-1.68)	1.16 (0.91-1.47)
Current smoker (ref: never or former smoker)	0.85 (0.70-1.02)	0.81 (0.67-0.99)	1.29 (1.02-1.64)	1.07 (0.83-1.37)
Current drinker (ref: never of former drinker)	1.20 (0.99-1.44)	1.26 (1.03-1.53)	1.05 (0.62-1.79)	0.86 (0.49-1.51)

CI, confidence interval; OR, odds ratio

Figures

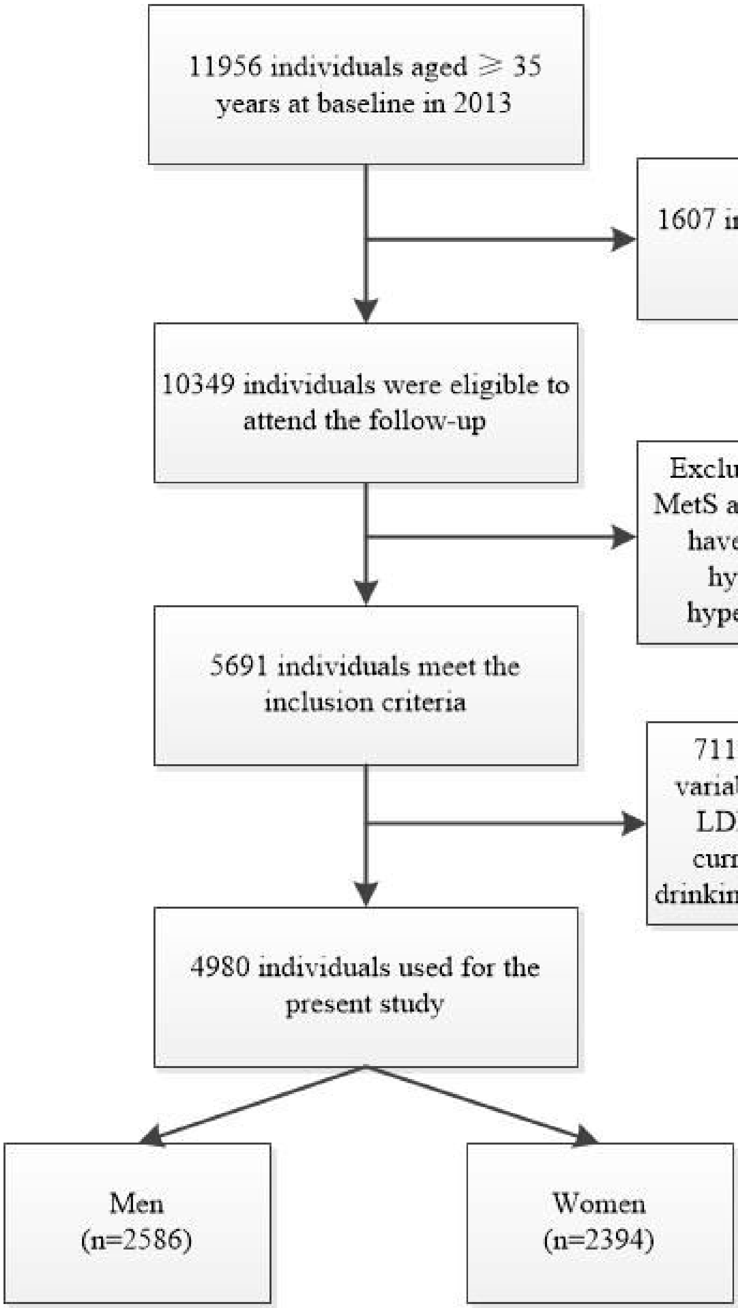

Figure 1

Flow chart of participants included in this study after inclusion and exclusion.

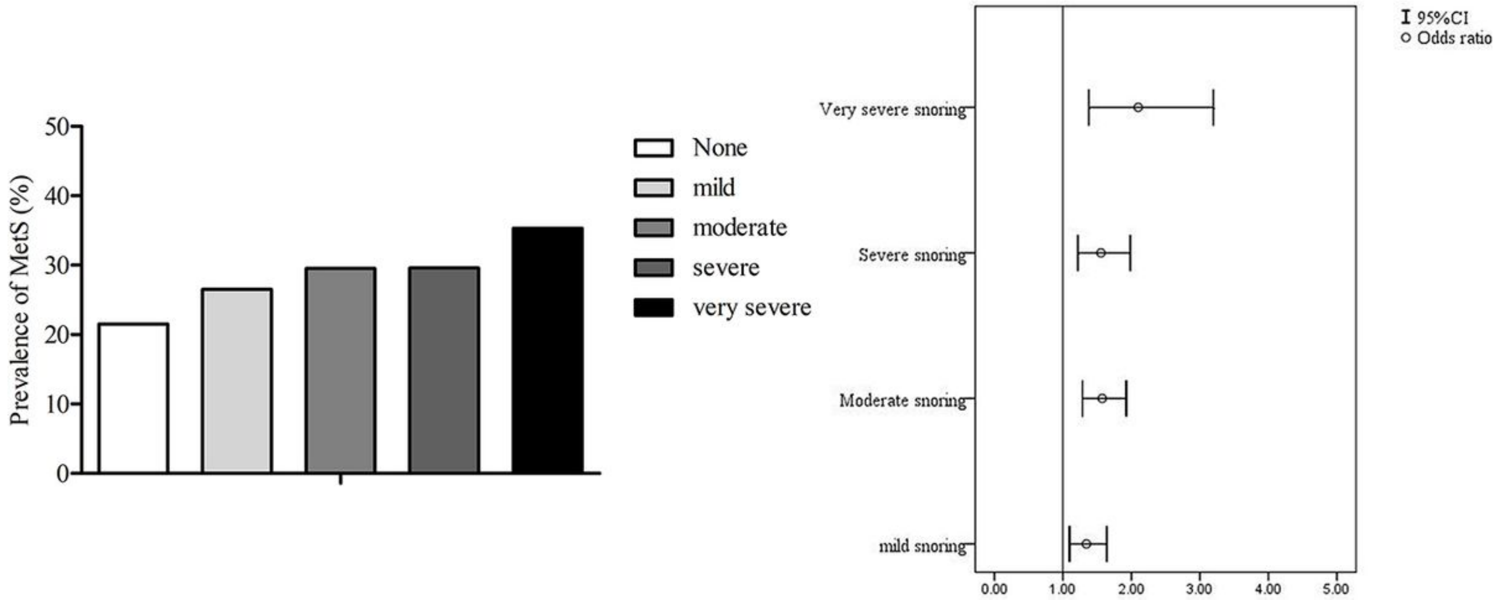

Figure 2

A. incidence of MetS among different snoring groups. B. Odds ratio and 95% CI for MetS among different snoring groups.